CLAIMS

1. High-strength steel sheet excellent in hole-expandability and ductility, characterized by;

comprising, in mass%,

C: not less than 0.01 % and not more than 0.20 %, Si: not more than 1.5 %,

Al: not more than 1.5 %,

Mn: not less than 0.5 % and not more than 3.5 %,

P: not more than 0.2 %,

S: not less than 0.0005 % and not more than 0.009 %,

N: not more than 0.009 %,

Mg: not less than 0.0006 % and not more than 0.01 %,

O: not more than 0.005 % and

Ti: not less than 0.01 % and not more than 0.20 % and/or Nb: not less than 0.01 % and not more than 0.10 %,

with the balance consisting iron and unavoidable impurities,

having the Mn%, Mg%, S% and O% satisfying equations (1) to (3), and

having the structure primarily comprising one or more of ferrite, bainite and martensite.

$$[Mg\%] \geq ([O\%]/16 \times 0.8) \times 24 \quad \ldots (1)$$

$$[S\%] \leq ([Mg\%]/24 - [O\%]/16 \times 0.8 + 0.00012) \times 32 \quad \ldots (2)$$

$$[S\%] \leq 0.0075/[Mn\%] \quad \ldots (3)$$

2. High-strength steel sheet excellent in hole-expandability and ductility described in claim 1, characterized by containing not less than 5.0×10^2 per square millimeter and not more than 1.0×10^7 per square millimeter of composite precipitates of MgO, MgS and (Nb, Ti)N of not smaller than 0.05 μm and not larger than 3.0μm.

3. High-strength steel sheet excellent in hole-

expandability and ductility described in claim 1, characterized by having Al% and Si% satisfying equation (4).

$$[Si\%]+2.2\times[Al\%]\geq 0.35 \quad \ldots (4)$$

4. High-strength steel sheet excellent in hole-expandability and ductility described in claim 2, characterized by having Al% and Si% satisfying equation (4).

$$[Si\%]+2.2\times[Al\%]\geq 0.35 \quad \ldots (4)$$

5. High-strength steel sheet excellent in hole-expandability and ductility described in any of claims 1 to 4, characterized by;

having Ti%, C%, Mn% and Nb% satisfying equations (5) to (7),

having the structure primarily comprising bainite, and

having a strength exceeding 980 N/mm^2.

$$0.9\leq 48/12\times[C\%]/[Ti\%]<1.7 \quad \ldots (5)$$

$$50227\times[C\%]-4479\times[Mn\%]>-9860 \quad \ldots (6)$$

$$811\times[C\%]+135\times[Mn\%]+602\times[Ti\%]+794\times[Nb\%]>465 \quad \ldots (7)$$

6. High-strength steel sheet excellent in hole-expandability and ductility described in any of claims 1 to 4, characterized by;

having C%, Si%, Al% and Mn% satisfying equation (8),

having the structure primarily comprising ferrite and martensite, and

having a strength exceeding 590 N/mm^2.

$$-100\leq -300[C\%]+105[Si\%]-95[Mn\%]+233[Al\%] \quad \ldots (8)$$

7. High-strength steel sheet excellent in hole-expandability and ductility described in claim 6, characterized in that;

not less than 80 % of crystal grains having a short diameter (ds) to long diameter (dl) ratio (ds/dl) of not less than 0.1 exist in the steel structure.

8. High-strength steel sheet excellent in hole-expandability and ductility described in claim 7, characterized in that;

not less than 80 % of ferrite crystal grains having a diameter of not less than 2 μm exist in the steel structure.

9. High-strength steel sheet excellent in hole-expandability and ductility described in any of claims 1 to 4, characterized by;

having C%, Si%, Mn% and Al% satisfying equation (8),

having the structure primarily comprising ferrite and bainite, and

having the strength exceeding 590 N/mm^2.

$$-100 \leq -300[C\%]+105[Si\%]-95[Mn\%]+233[Al\%] \quad \ldots (8)$$

10. High-strength steel sheet excellent in hole-expandability and ductility described in claim 9, characterized in that;

not less than 80 % of crystal grains having a short diameter (ds) to long diameter (dl) ratio (ds/dl) of not less than 0.1 exist in the steel structure.

11. High-strength steel sheet excellent in hole-expandability and ductility described in claim 10, characterized in that;

not less than 80 % of ferrite crystal grains having a diameter of not less than 2 μm exist in the steel structure.

12. A method for manufacturing high-strength steel sheet excellent in hole-expandability and ductility, which has the structure primarily comprising ferrite and martensite and a strength in excess of 590 N/mm^2, characterized by the steps of;

completing the rolling of steel having a composition described in any of claim 1 to 4 at a finish-rolling temperature of not lower than the Ar_3

transformation point,

cooling at a rate of not less than 20 °C/sec, and

coiling at a temperature below 300 °C.

13. A method for manufacturing high-strength steel sheet, excellent in hole-expandability and ductility, which has the structure primarily comprising ferrite and martensite and a strength in excess of 590 N/mm^2, characterized by the steps of;

completing the rolling of steel having a composition described in any of claims 1 to 4 at a finish-rolling temperature of not lower than the Ar_3 transformation point,

cooling to between 650 °C and 750 °C at a rate of not less than 20 °C/sec,

air-cooling at said temperature for not longer than 15 seconds,

re-cooling, and

coiling at a temperature below 300 °C.

14. A method for manufacturing high-strength steel sheet, excellent in hole-expandability and ductility, which has the structure primarily comprising ferrite and bainite and a strength in excess of 590 N/mm^2, characterized by the steps of;

completing the rolling of steel having a composition described in any of claims 1 to 4 above at a finish-rolling temperature of not lower than the Ar_3 transformation point,

cooling at a rate of not less than 20 °C/sec, and

coiling at a temperature of not lower than 300 °C and not higher than 600 °C.

15. A method for manufacturing high-strength steel sheet excellent in hole-expandability and ductility, which has the structure primarily comprising ferrite and bainite and a strength in excess of 590 N/mm^2,

characterized by the steps of;

completing the rolling of steel having a composition described in any of claims 1 to 4 above at a finish-rolling temperature not lower than the Ar_3 transformation point,

cooling to between 650 °C and 750 °C at a rate of not less than 20 °C/sec,

air-cooling at said temperature for not longer than 15 seconds,

re-cooling, and

coiling at a temperature of not lower than 300 °C and not higher than 600 °C.